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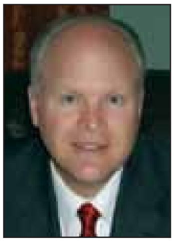

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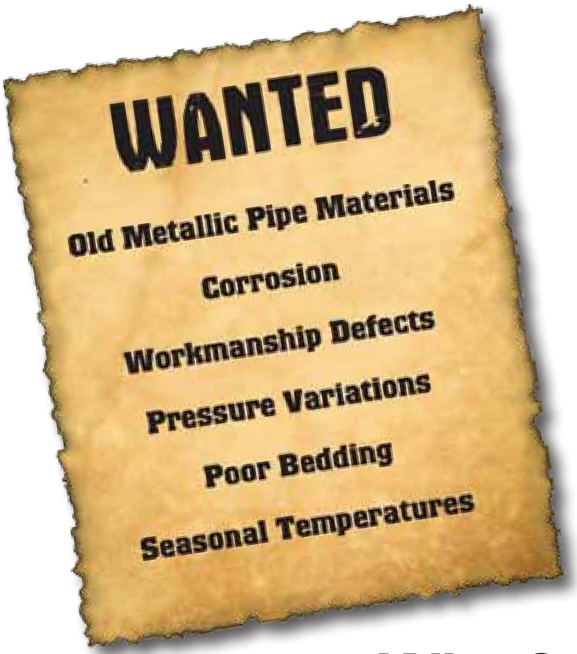

Who Stole my Water?

The Case for Water Loss Control and Annual Water Audits

In a water-scarce western town in the United States a cry is heard as a bank teller rushes out into the street. "We've been robbed! Call the sheriff!" Soon, the mayor and town officials gather around. "How much is missing?" the sheriff asks. "Well, we don't rightly know. We haven't really counted for three or four years," the teller states sheepishly. "But the vault's a lot more empty than what it was last month!" The town officials demand that the sheriff deputize some men to form a posse and chase down the outlaws to bring 'em to justice.

In many communities across the United States, the same kind of concern is being raised as utility staff begin to assess the water and revenue losses from their water supply operations. Many utility managers, or water sheriffs, may understand that a certain amount of their treated water is going missing and not collecting revenue, but without careful accounting and investigation, managers don't know the nature and extent of their losses or how to best chase down the culprits and correct the problem.

PROTECTING THE BANK

Water utilities are investing in demand-side (customer) conservation programs and placing controls and restrictions on the customer to reduce water demand. This scenario has contributed to the decline in variable customer water demand in many communities, but sometimes an unexpected decline in revenues also results, creating financial instability. However, fewer utilities have structured water loss control programs to control supply-side losses. Water loss control saves water, reduces operational costs (through the water–energy nexus), and can improve the financial bottom line by netting uncaptured revenue and lowering production costs. Sometimes, in an attempt to address water loss issues, water utilities have rushed to purchase leak detection devices, but without the results of routine water audits, the investment may not be focused in the greatest area of need, and to the degree required to gain the greatest benefit. Furthermore, some utilities focus on additional water supply augmentation projects at very high costs and have done so without adequately ensuring an ongoing water-loss control and annual water-audit process is in place to demonstrate current water resource stewardship and justify any future water supply investments.

George Kunkel, Philadelphia (Pa.) Water Department's (PWD) water efficiency program manager and a former chair of AWWA's Water Loss Control Committee, recently said: "The water industry is at a state of imbalance. Water is undervalued and underpriced, and there exists a disconnect in what a utility manages. Utilities should be accountable for the volume or quantity of water they are using. This raises an accountability-versus-efficiency issue." Kunkel added, "One can be accountable and have various levels of efficiency. But one can't tout that they are water efficient if they are not first accountable. In order to be accountable for the water resources used, all utilities should compile water audits by following a standard methodology and consistent process of data gathering, analyzing, and reporting on an annual basis."

Who's trying to rob the bank? The US water distribution systems are aging, and many pipes in this infrastructure are beginning to leak or fail altogether. Leakage from water distribution systems costs the nation $1 billion to $2 billion annually, and this figure grows when taking into account property damage and replacement costs caused by infrastructural failures. Leaks in the water infrastructure do not have to be large to have a major effect on water loss. Large water-main breaks receive much more media attention, but these types of failures only account for 1% of water loss caused by leaks. A chronic service-line leak on the order of 1 gpm can go unnoticed for years before being found, resulting in the loss of 525,000 gallons of water per year—water that was treated and purified to meet drinking water standards, which increases the costliness of leaks (USEPA, 2010).

In most water-related cases, one would consider the US Environmental Protection Agency (USEPA) to be the law, but USEPA's primary regulatory focus for drinking water centers around health effects and water quality, with only limited regulatory rigor around water "quantity" issues. Utility management and governance structures are the self-policing entities within a utility. This authoritative paradox of self-governance for water and wastewater utilities viewed as natural monopolies by the public has driven the need for additional transparency and extensive monitoring and reporting. Many utilities encounter external pressure to develop benchmarking performance programs and attempt comparative peer analysis. Two specific areas of major public concern include the amount of water loss and the costs of repairing and replacing aging infrastructure. The remedy to these ratepayer concerns includes water audits, asset management, and replacement planning.

The water audit process is similar to financial audits conducted by accountants and compares volumes of water treated and pumped to volumes consumed by customers and for uses such as firefighting and other community uses. Estimated volumes of losses because of leakage (real losses) and metering and accounting inaccuracies (apparent losses) can be quantified during the water audit process. Currently there is no national requirement for routine water auditing in North America (AWE, 2011a). In an industry that supports green innovation and sustainability, the theme "go blue" is a growing trend toward setting an example of water quantity accountability in the worldwide water scarcity debate.

According to AWWA's Water Loss Control Committee, water-usage data published by the United States Geological Survey (USGS, 1998) shows that of 40 bgd of water withdrawn by utilities in the United States, only 34 bgd of this amount is documented as end-user consumption. The missing 6 bgd is categorized simply as "public use/loss," reflecting USGS's recognition that unmonitored public use (e.g., firefighting, street cleaning), accounting shortcomings, and leakage inhibit the ability to obtain a true balance of withdrawal and use totals. The quantity of water labeled as "public use/loss"—which is more than enough to meet the water needs of the 10 largest US cities combined—reflects the huge margin of error that currently exists in quantifying actual water use amounts versus water loss amounts in drinking water utilities. By consistently using a reliable and standardized water-audit method, the North American water industry should gradually improve the reporting accuracy for its water delivery components of valid usage and losses (AWWA Water Loss Control Committee, 2003).

In a 2001 survey of 28 regulatory agencies representing 23 states and 3 regional authorities, all reported the use of some type of standard or benchmark for water losses. One fact that emerged was that there is a lack of clear consensus on reporting standards. Another finding was that "unaccounted-for" water loss standards ranged from 7.5 to 20%. The water loss percentages mostly referred to production water losses (Beecher, 2002).

Texas is a progressive leader in state water audits. The first state to require utility water audits on a routine basis, Texas learned some difficult lessons when first gathering data from utilities. "Water loss minimization is a very important water conservation strategy for retail water suppliers. Historically, retail public utilities have lacked detailed knowledge about their water loss performance. This is due partially to a lack of careful water auditing and partially to inconsistent water loss reporting using non-uniform statistics, including the use of 'unaccounted for water' percentage to compare performance. As a result, utilities may not know whether their water losses are due to leaks, accounting practices, theft, metering problems, or other factors, and may have difficulty developing water loss minimization strategies" (TWDB, 2007).

The first broad analysis of water loss for retail public utilities from more than 2,000 Texas water audits in 2005 showed that

- Approximately half of retail public utilities in Texas reported their water loss data.
- Reporting utilities serve as much as 84% of the state's population.
- A substantial amount of water (the balancing adjustment) was not attributed to any water-use category, causing significant uncertainty in estimates of water loss and unaccounted-for water.
- Reporting utilities experienced total water loss of 212,221–464,219 acre-feet per year, or 5.6–12.3% of all water entering the reporting systems.
- On the basis of the 2004 statewide average municipal water use of 150 gpcd, equivalent water volumes could supply between 1.3 million and 2.7 million Texans.
- Reporting utilities experienced unaccounted-for water of 311,333–563,331 acre-feet per year, or 8.3–15.0% of all water entering the reporting systems.
- When extrapolated to all retail public utilities in Texas, the statewide value of total water loss is estimated to be between $152 million and $513 million per year.
- Reporting utilities may have underestimated their real water loss (TWBD, 2007).

Drought can be a robber. Chronic water-supply problems in many areas of the West are among the greatest challenges today and will worsen in the coming decades. The increased demands for water are a result of exploding population, increasing water needs of urban areas, settlement of the Native American water rights claims, and ecosystem needs including compliance with the Endangered Species Act. These demands run up against limits imposed by already over-allocated watersheds and aging facilities even in nondrought years. The extended drought occurring in the West magnifies already stressed water supply conditions, particularly in important river basins such as the middle Rio Grande and Colorado River. Crisis management is not an effective response to drought, nor is it an effective solution to long-term, systemic water supply problems. Today's water supply issues require innovative, locally based, regionally supported approaches that identify solutions in advance of water supply crises (Bureau of Reclamation, 2007).

The 2011 summer drought index shows Texas in deep red (USDOI, 2003), and past droughts have also had long-lasting effects in the West (Luebehusen & Edwards, 2011) in the context of reducing water supplies. But in Texas, the soil is so dry that the conditions have accelerated the frequency of water main breaks. In Houston, the mayor reported that during the summer there are normally 200 main breaks a day, but in August it has climbed to 700 main breaks a day (Llanos, 2011).

Enter the posse. The new Texas water audit reporting requirements follow a methodology that is recommended by the International Water Association (IWA) and the AWWA Water Loss Control Committee. AWWA participated in a five-country task force formed by IWA to develop a best-practice water-audit structure for drinking water utilities. The task force published its results in *Performance Indicators for Water Supply Services* (Alegre et al, 2000). This methodology relies on strictly defined water use categories and water loss performance indicators and is becoming the international water loss accounting standard.

AWWA's Water Loss Control Committee advocated the use of the IWA/AWWA water audit methodology in its 2003 report "Applying Worldwide BMPs in Water Loss Control" (AWWA Water Loss Control Committee, 2003). The recent JOURNAL article "Piloting Proactive, Advanced Leakage Management Technologies" (February) showcased the PWD's efforts as a clear example of how to apply the water audit method to sustain infrastructure and preserve water supplies while staying within a limited budget (Kunkel & Sturm, 2011).

Better get a badge. Buy the badge, the tool is free. The third edition of AWWA's Manual M36, Water Audits and Loss Control Programs, is the first publication in North America to provide detailed and comprehensive instructions on the IWA/AWWA water audit methodology. AWWA's Water Loss Control Committee maintains the manual, and its members are involved in water auditing, leak management, and revenue protection programs for water utilities around the world. The worldwide value of lost water and its associated revenue is estimated at $15 billion annually.

The AWWA Water Loss Control Committee also offers the Free Water Audit Software© (www.awwa.org/Resources/WaterLossControl.cfm?ItemNumber=48511), which is available to all users. The software is in Microsoft Excel format and is a useful and easy way to compile a basic audit of water supply and billing operations. The software is not intended to provide a full and detailed water audit (reference M36for guidance on comprehensive auditing procedures). However, the software allows water utilities to quickly compile a preliminary "top-down" audit in the standardized and transparent manner advocated by AWWA (2011a).

Chasing down the robbers. The IWA/AWWA water audit method is effective because it features sound, consistent definitions for the major forms of water consumption and water loss encountered in water utilities. It also features a set of rational performance indicators that evaluate utilities on system-specific attributes such as the average pressure in the distribution system and total length of water mains.

The performance indicators allow water utilities to make a meaningful assessment of their water loss standing, benchmark themselves with other water utilities, and set performance targets. The water audit informs the utility about how much of each type of loss occurs and how much it is costing. The key concept around this method is that all water is quantified—via measurement or estimate—as either a form of beneficial consumption or as a wasteful loss. A cost is placed on each volume component in order to assess its financial impact to the water utility (AWWA, 2011b).

Studies have shown that dated practices of calculating "unaccounted-for" water varied so widely in utilities around the world that the term had no consistent definition. The water audit methodology dictates that all drinking water can be accounted for, by metering or estimation, as either a form of beneficial consumption or a wasteful loss. AWWA strongly recommends avoiding use of the term "unaccounted-for" water and using the specifically defined term "nonrevenue water."

The Water Loss Control Committee also concluded that regardless of the water system size, water loss should be expressed in terms of actual volume, not as a percentage. This volumetric measure, the committee points out, is essential for quantifying the monetary value of losses. The volumetric measure of lost water can be multiplied by the unit cost of water production or the retail rate to estimate the value of the lost water. From an economics perspective, the true value of losses is the marginal or incremental unit cost of production, that is, the cost of producing the next increment of drinking water supply. Incremental or marginal costs more accurately reflect the water's resource value, which will increase as supply alternatives become scarcer. Reducing leakage helps systems capture a supply resource and avoid costly supply-side operating and capital costs (AWWA Water Loss Control Committee, 2003).

Benchmarking the trail. Any benchmarking project is a demanding endeavor that needs to involve all levels of the organization and receive its full support, including from senior management. In the past 20 years, many benchmarking projects have been undertaken in the water industry all over the world. Usually the utility management, with its operational responsibility for the service, has its own drivers to benchmark. The drive to continuously improve the organization and its products can be facilitated in benchmarking projects that provide detailed insight into utility performance and identify areas and means of improvement. The relative position of the utility compared with its peers can help determine the level of urgency for taking measures in the areas that have been analyzed. The comparison of results from performance assessments can help both governments and regulators introduce artificial competition in the sector (which constitutes a natural monopoly) and put pressure on utilities to raise efficiency and transparency. Utility stakeholders and bondholders require insight about utility performance, efficiency in its operations, financial sustainability, and proper risk assessment. Regardless of the purpose, the performance-assessment system needs to be well-designed and tailor-made for its objective. *Benchmarking Water Services*, a new manual of best practice, is a comprehensive guide for developing a benchmarking process and performance indicators (Cabrera et al, 2011).

Don't lose the trail. Staying on the trail of water loss bandits and benchmarking for improvement can potentially create some obstacles. Barriers to monitored performance may include beliefs that the utility is considered to be unique and not comparable to others, there is a lack of reliable data to submit, there are not enough available resources (i.e., budget, manpower), there is no stable situation for assessing performance, there are doubts on the added value of the program, the suggested methodology is too complicated, and there is no guarantee for confidentiality of individual performance data (Cabrera et al, 2011). Added to this debate are possible reasons for not implementing a comprehensive distribution-side water loss control program, which can include fears of political backlash from admitting system leakage, falsifying water accounting records, lack of understanding that recapturing nonrevenue water with an upfront investment makes for a great business case with fast payback, and inherent mistrust of anyone outside the utility examining system data (Dickinson, 2005).

Posting a reward. When comparing demand-side customer conservation program cost with distribution-side conservation program (water loss control program) cost, it often becomes clear that the cost effectiveness of distribution-side conservation programs can be equal to or, in many cases, better than the cost effectiveness of demand-side conservation programs. The water saved through reduction of real losses (leakage) makes available new sources that can be used for additional supply, helping to avoid or reduce the need for demand restrictions during periods of drought, and easing the pressure on the environment and water resources.

It is a main responsibility of the water utility to manage both the demand and supply of water responsibly and efficiently. Distribution-side conservation through reduction and efficient management of system water losses provides real benefits to a water utility. These benefits include

- finding the economic level of water and revenue losses, which allows setting of economic targets;
- improving public health protection;
- increasing the level of service provided to customers through increased reliability of water supplies;
- providing for better assurance of future water needs and resiliency from shortages;
- reducing pressure on water resources and therefore environmental improvement;
- deferring capital expenditures on water resources development and new supply schemes;
- improving public perception of water companies; and
- applying best leakage-management practices reducing liability to the water supplier (Sturm & Thornton, 2007).

COST AND SAVINGS OF WATER LOSS CONTROL PROGRAMS

In order to evaluate the cost of distribution-side conservation programs, eight systems and their water loss control programs were analyzed (Sturm & Thornton, 2007). The cost for the programs includes the cost for detailed audits and assessment of economic optimum volume of losses, the cost for the leak-detection program, and the repair of the leaks. The estimated average cost for the entire program, including the cost for the detailed water audits that formed the basis for the intervention program and the cost to detect and repair the leaks was calculated, as listed here.

- San Francisco (Calif.) Public Utilities Commission: $439/acre foot of water saved
- Nashville (Tenn.) Water Works: $318/acre-foot of water saved
- Los Angeles (Calif.) Department of Water & Power: $347/acre-foot of water saved
- California Department of Water Resourses (1998 Water Audit and Leak Detection Program) $658/acre-foot of water saved
- Las Vegas Valley (Nev.) Water District: $464/acre-foot of water saved
- Unnamed large utility in the western United States: $318/acre-foot of water saved
- Orange County (Fla.) Utilities: $463/acre foot of water saved

The average avoided retail cost of an acre-foot of water was $1,030/acre-foot (Sturm & Thornton, 2007).

Several states and regulatory agencies have begun to institute the use of standardized water audits including Texas, New Mexico, Georgia, Washington; the California Urban Water Conservation Council, the Delaware River Basin Commission (which includes the states of New Jersey, Pennsylvania, Delaware, and New York), and the US Army Corps of Engineers. The Pennsylvania Public Utility Commission and the Tennessee Association of Utility Districts are also pursuing water audit requirements using the IWA/AWWA water audit methodology (AWE, 2011b).

Forming alliances. Both distribution-side and supply-side conservation efforts should be a part of every utility's effort to manage its water resources effectively. The Alliance for Water Efficiency (AWE) is a stakeholder-based nonprofit organization dedicated to the efficient and sustainable use of water. Headquartered in Chicago, Ill., AWE serves as a North American advocate for water efficient products and programs, and provides information and assistance on water conservation (AWE, 2011c).

AWE has developed a Water Conservation Tracking Tool (free to its members) which is a spreadsheet-based model that can evaluate the water savings, costs, and benefits of conservation programs for a specific water utility. With information entered into the tool from the utility's system, the model provides a standardized methodology for water savings and cost–benefit accounting and includes a library of predefined conservation activities from which users can build conservation programs. The tool helps develop long-range conservation plans by tracking and estimating the costs and savings of up to 50 different conservation measures. The different versions account for the various plumbing codes and appliance standards for different states (AWE, 2011d).

The investigation. It is paramount for the success of any intervention program or any investment in leak-detection equipment, no matter how expensive and sophisticated the equipment might be, that the utility routinely compiles a detailed water audit in order to gain the necessary understanding of its water losses. There are three major phases in a comprehensive water loss control program—(1) the water audit phase including analysis of real losses and the costs, (2) the intervention strategy phase, and (3) the result evaluation phase.

Water loss control is likely one of the most cost-effective and efficient methods of water conservation available to water utilities today. If a utility does not have the internal personnel resources, many firms are available to support the process by providing sustainable solutions to controlling water losses by undertaking prudent evaluations of volumes and types of water loss, applying a value, developing an economic business case for intervention, selecting the correct tools for the job, and supervising and reporting on the implementation of the loss reduction and control programs (Thornton International, 2005).

In 2010, for the thirteenth consecutive year, Philadelphia Water Accountability Committee compiled a water audit report of the water-supply operations and customer-consumption tracking of the city of Philadelphia using the best practices method advocated by the AWWA and IWA. The method tracks quantities of water supplied and balances these volumes against customer-billed consumption and losses categorized as apparent losses, or nonphysical losses, resulting from customer meter inaccuracies, data/billing error, unauthorized consumption; and real losses, or actual physical losses—mainly leakage. Apparent losses are valued at higher costs than leakage and have a substantial financial effect in terms of lost revenue for utilities that bill customers based on metered consumption. Real losses waste water resources and cause excessive production costs. New technologies have also been developed to help investigate leak issues that operate in pressurized water mains while providing high-quality closed-circuit television visuals, precise acoustic leak detection, and tracking/mapping capabilities through a single, advanced tethered sensor. Next-generation technology can be launched through fire hydrants, pressure fittings, air valves, gate valves, and flow meter fittings at the main's full pressure to find leaks and assess condition (Wachs Water Services, 2011).

Locating the hideouts. The PWD water audit itemizes the cause and cost of real losses from tank overflows/operator error, reported and unreported leaks, leakage from transmission main leaks and breaks, distribution main leaks and breaks, customer service lines, hydrant and valve leaks, and measured leakage from district metered areas (DMAs), background leakage, and liability costs.

Bringing 'em to justice. A key strategy in leakage management is to quickly identify active leaks and quickly abate them. PWD's previous leak-repair practices often resulted in known leaks running at length while awaiting repairs. More important, leak-repair documentation was unreliable in the current environment of multiple legacy computer databases that have evolved over several decades. PWD's initiative to improve its leakage management depends not only on applying effective leakage-control techniques, but also on the ability to implement timely and lasting repairs. In 2009 PWD obtained the leading geographic information system–centric public asset management computerized maintenance-management software (Cityworks, Azteca Systems Inc.) and launched its implementation schedule, which was scheduled to be phased in over 18–24 months. The new system holds stronger potential for improved scheduling and tracking of leakage repairs, work history, costs, and performance.

PWD is a recognized US water industry leader in instituting innovative leakage-control techniques. PWD has operated a traditional acoustic leak-detection program for more than 30 years and is also one of the first US water utilities to establish a large-diameter transmission piping leak-detection program using inline acoustic leak-detection technology. Under an industry-sponsored research project (Fanner et al, 2007), the PWD designed and constructed its first permanent DMA to demonstrate the benefits of continuous leakage monitoring and advanced pressure reduction. PWD's 2010 water audit indicates real (leakage) losses of 21,739 million gallons (59.6 mgd). However, leakage has been reduced from a level of roughly 90 mgd in the early 1990s. The Infrastructure Leakage Index (ILI) for PWD stood at 9.9 in 2010 compared with more than 13.0 in 2000, when PWD first audited its system using the IWA/AWWA water audit methodology. The ILI represents the ratio of current leakage to the theoretical low level of leakage known as the Unavoidable Annual Real Losses. Although rising slightly in 2010, PWD's leakage levels are still greatly reduced from levels in previous decades. Most important, PWD uses standard annual reporting of its losses in order to reliably track its loss standing and measure the effectiveness of its loss control interventions. PWD has saved more than $23 million through its water loss control and revenue protection program since 2000 (Kunkel, 2011).

Identifying the outlaws. Leaks and water main breaks occur in water distribution systems for a variety of reasons including piping materials not suitable for corrosive soils that cause them to fail prematurely, aging pipes, workmanship defects, corrosion, heavy traffic loading, pressure variations or transients, poor bedding or backfill material, and seasonal fluctuations in temperature.

Give 'em a fair trial then hang 'em high. Some water loss perpetrators such as extreme seasonal fluctuations and drought are not within our immediate control. Other water loss culprits such as pipe materials, corrosion, and installation and workmanship issues do fall within our control. Corrosion, leaks, and breaks in old-technology pipe materials are degrading our water delivery and sewage treatment systems, which are critical to public health and the environment. It is reported that 850 water main breaks occur every day in North America at a total annual cost of more than $3 billion (some experts have put the average at more than 1,350 water main breaks per day, and considering the number of breaks cities like Houston, Texas, have been experiencing, it may be much higher). This does not include the high cost of emergency equipment, depleted water supply, traffic disruptions, and lost work time. Experts note that corrosion is the leading cause of the main break epidemic and is costing US drinking water and wastewater systems more than $50.7 billion annually in terms of breaks, replacement of corroded pipes, and the implementation of costly corrosion-mitigation measures. Leaking pipes lose 2.6 trillion gallons of drinking water every day, or 17% of all water pumped in the United States. This represents $4.1 billion in wasted electricity annually. Ninety percent of lost-water costs are corrosion-related (Watermainbreakclock, 2011).

As a result of these corrosion issues and concerns, many water systems have been increasing the amount of nonmetallic pipe-replacement materials like the various type of long design life, durable, corrosion-resistant polyvinyl chloride (PVC) pipes that are available. Also, as part of the asset management pipe-replacement planning process, a growing trend has been to include PVC as the replacement pipe option (over old gray cast iron and ductile iron) with an estimated life of nearly 100 years in order to reduce overall long term pipe replacement capital plans.

The jury. The Water Loss Control Committee has been active in 2011 working with a number of progressive water utilities that now use standardized water auditing. Water audit data from more than 20 of these systems are posted on the Water Loss Control pages of the AWWA website. This information, as well as a wealth of water loss control information, can be found by going to www.awwa.org/Resources/WaterLossControl.cfm?ItemNumber=47846&navItemNumber=48155.

The judge. Greater accountability of how the water industry tracks and reports its efforts is inevitable with looming rate hikes and large capital replacement plans. Dedicated water industry professionals continue to develop and distribute valuable resources and tools that can more fully demonstrate the industry's ability to manage utilities effectively and responsibly. A water loss control program and annual water audits are powerful tools that better focus limited resources toward the most critical needs in the most publicly defensible and cost-effective manner. John Wayne once said: "Courage is being scared to death . . . and saddling up anyway." Service and stewardship in the water industry are calling for a courageous step-up in action.

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